Predictive maintenance in disc mills using sensory signal monitoring

Abstract

Disc mills are used to comminute sample material for analysis by XRF, XRD or other methods. Here we present a method for predictive maintenance (PdM) monitoring the anchor bolts joining the drive motor to the swing aggregate. Based on acceleration evaluation by the PrepMaster Analytics software the impending failure of the bolts was clearly detected several days before actual breakage of bolts. This time period was long enough to schedule the necessary maintenance tasks in a timely manner. This case study underlines the potentials of PdM to maximize availability and cost efficiency of an automated system.

Key words

• **Disc mill** • **Predictive maintenance**• **Swing aggregate** • **Acceleration**

Introduction

Disc grinding mills are standard equipment used for comminution of non-organic material in preparation for analytical procedures like, e.g., X-ray fluorescence or diffraction. Typical target grain sizes are between 20 and 150 µm depending on the analytical application. In order to start the grinding process, a motor puts the grinding vessel into an eccentric circular motion. This again will lead to a circular movement of the grinding set inside the grinding vessel. Depending on the grinding mill type, material and analytical method, different types of grinding sets are used including disc, ring and/or stone. The particles are ground based on shearing, impacting and compression of the material between grinding set, wall of the vessel and among each other (Figure 1).

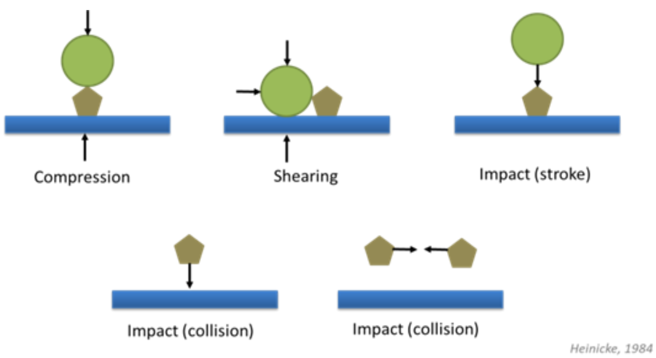

Figure 1: *Grinding mechanisms taking place in a disc mill include compression, shearing and impacting. (modified from Heinicke, 1984)*

The energy to be added to the grinding system has to be large enough to achieve an efficient particle size reduction especially for brittle material. The strength of the grinding process is usually controlled by the rotation speed of the grinding vessel generated by the drive motor mounted to the swing aggregate. An increase in the rotation speed results in higher acceleration of the grinding vessel and eventually higher energy available for comminution. In large volume mills, accelerations of 10 g and more are achieved.

High gravitational acceleration values pose great demands on the mechanical joining elements between the drive motor and the swing aggregate. Usually, this is not causing a problem because anchor bolts are made of high-quality steel and are specially fixed. In rare occasions, however, a breakage of the bolts might occur resulting from a material defect or material fatigue.

In this application note we present a method for detection of an impending failure well before the actual breakdown of the grinding mill.

The method is based on sensory acceleration technology and makes an important contribution to predictive maintenance (PdM) strategies for laboratory systems

Method

An acceleration sensor was mounted on the lower half of the swinging aggregate and connected to the PLC of the grinding mill for data acquisition. The sampling frequency of the sensor was 100 Hz. For analysis of the grinding vessel motion, the vector from acceleration in x- and y-direction was calculated for each point of time. Additionally, the length of the combined x-/ and y-vector was evaluated by calculation of the root mean square (RMS).

Acceleration vectors in each segment were evaluated by visual inspection as well as using statistical characteristics including mean and standard deviation. Data collection, display and analysis were performed by the TCM module of the PrepMaster Analytics software.

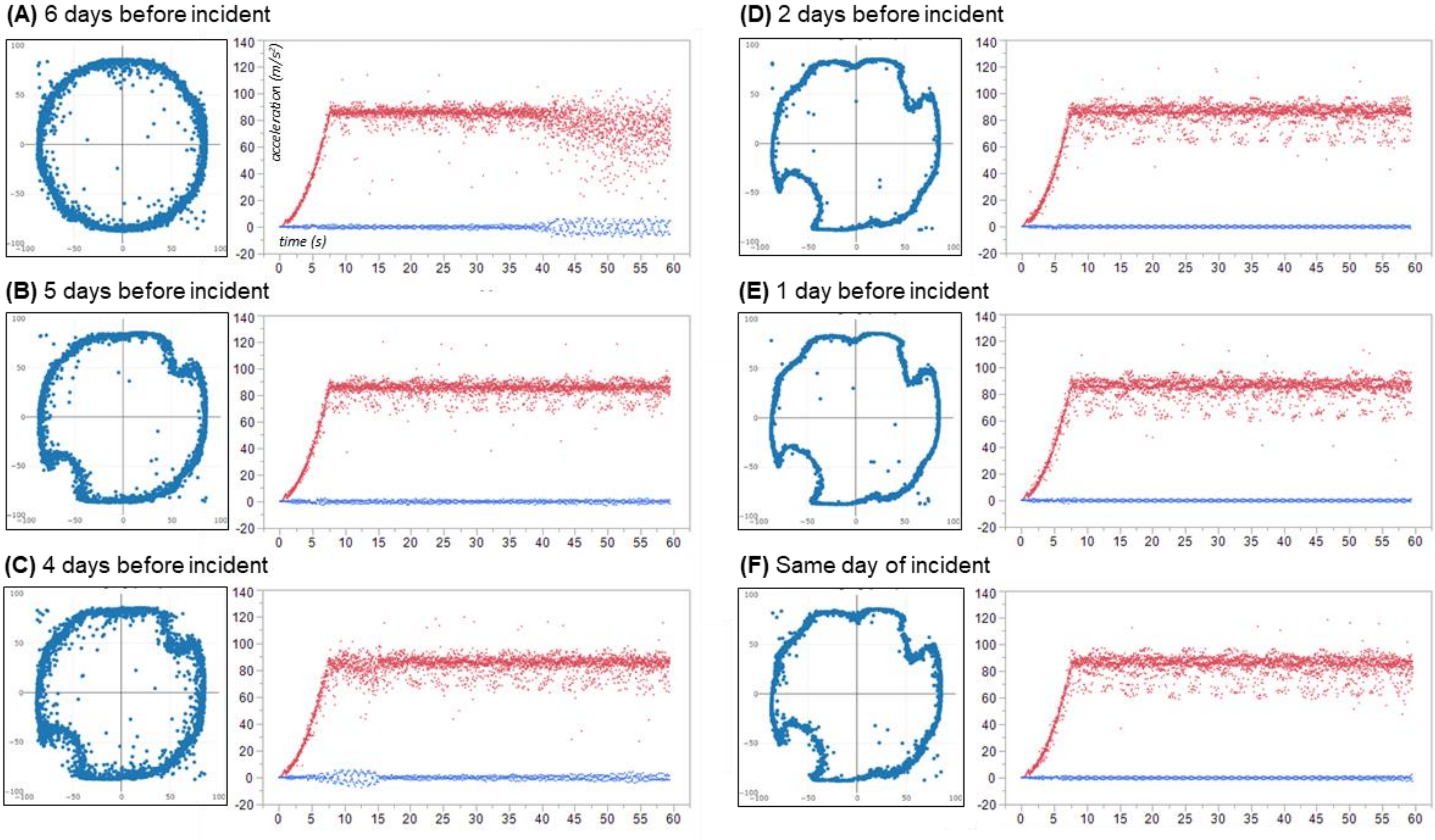

Figure 2: *Display of acceleration x-/y- vectors (left box) and RMS values (red dots, right box) in the period before incident with breakage of anchor bolts between drive motor and swing aggregate. Six days before (A) only small deviations in the acceleration could be observed. In the subsequent period of time (B- F) a significant progressive deviation occurred.*

The data presented in this application note were obtained from an automatic HP-M 1500 mill used for grinding of iron ore and other material.

Results

Six days before the breakage of two anchor bolts joining the drive motor to the swing aggregate no unusual findings were detected (Figure 2, A). Retrospectively, small deviations from the circular path were identified in the segments at 60° (upper right) and 240° (bottom left). Furthermore, the plot of RMS values over time (red dots, Figure 2, A) showed a slight increase in range.

Five days before the incident, we observed for the first time a clear inward rotation of the x-/y-acceleration vector at 60° and 240° (Figure 2, B). The RMS values were broadened resulting in a "ghosting" phenomenon. At that time, grinding results showed no visually recognizable change in particle composition. It must, however, be taken into consideration that grain size distribution was not determined accurately using a grain sizer or sieving machine. Inspection of the swing aggregate revealed slight loosening and bending of one anchor bolt without affection of further bolts. We decided to continue the grinding trials without changing the damaged bolt in order to follow-up the further development of the acceleration signal.

On the subsequent day (Figure 2, C), no further alterations of the acceleration curve and condition of anchor bolts were recorded.

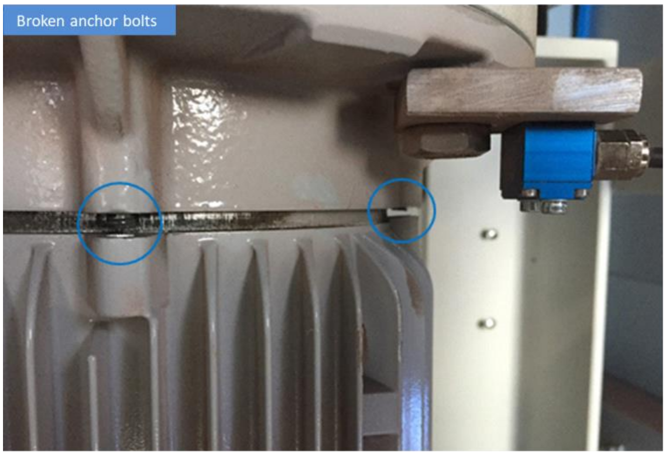

Figure 3: *Picture of two adjacent anchor bolts joining the drive motor and the swing aggregate in the disc grinding mill HP- M 1500*

Two days before bolt breakage we noted an increased deformation of the acceleration curve (Figure 2, D). This was accompanied by loosening of a second adjacent bolt.

Subsequently, no significant change in the sensory signal and outer appearance of anchor bolts was identified until two neighbouring bolts suddenly broke apart (Figure 3). This incident was clearly visible in the acceleration recording leading to a sudden and marked reduction of acceleration (Figure 4). Hereafter, it was not possible to achieve the targeted grinding results.

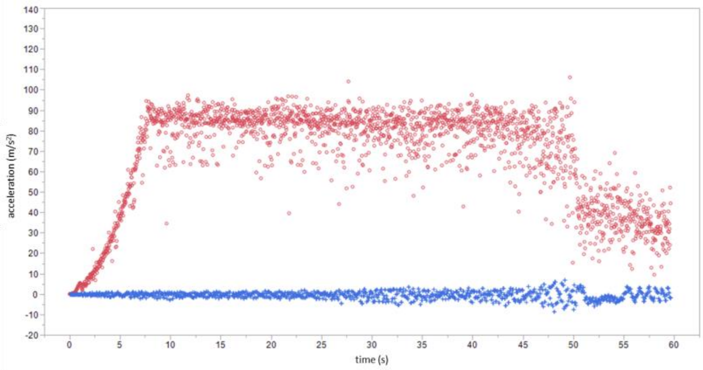

Figure 4: *Display of the RMS of the x-/y- acceleration (red dots) and z-acceleration (blue dots) showing the breakage of the anchor bolts.*

Discussion

In this application note we demonstrate that evaluation of the acceleration sensor signal is capable to predict the failure of anchor bolts connecting the drive motor to the swing aggregate. Between first detection of sensory abnormalities and final bolt breakage approximately 250 grinding trials were performed. This time interval is sufficiently long to schedule the exchange of bolts in a timely manner and avoid sudden machine breakdown affecting laboratory availability.

This feature is in accordance with the main aim of PdM which is first to predict whether and when equipment failure might occur, and secondly, to prevent failure by performing timely maintenance. Ideally, PdM keeps the maintenance frequency as low as possible, prevents unplanned reactive maintenance and lowers the need for preventive maintenance.

PdM makes use of condition-monitoring technologies to evaluate an asset's performance in real-time. It relies on sensors to capture information, make sense of it and identify areas that need attention. We have previously shown that the same acceleration sensor technology is also applicable for monitoring the status of the swing aggregate and wear of the grinding set (see application notes no. 25 and 26).

The PrepMaster Analytics software provides all means for digestion, display and interpretation of incoming data. PdM and Tool Condition Monitoring (TCM) are integral parts of smart industry solutions for process management and optimization. PrepMaster Analytics combines powerful TCM and PdM tools and provides the user with a holistic view not only on the machine state but the complete laboratory. It therefore enables the laboratory to gain maximum repeatability, accuracy and availability.

Germany

HERZOG Maschinenfabrik
GmbH & Co.KG
Auf dem Gehren 1
49086 Osnabrück
Germany
Phone +49 541 93320
info@herzog-
maschinenfabrik.de
www.herzog-maschinenfabrik.de

USA

HERZOG Automation Corp.
16600 Sprague Road, Suite 400
Cleveland, Ohio 44130
USA
Phone +1 440 891 9777
info@herzogautomation.com
www.herzogautomation.com

Japan

HERZOG Japan Co., Ltd.
3-7, Komagome 2-chome
Toshima-ku
Tokio 170-0003
Japan
Phone +81 3 5907 1771
info@herzog.co.jp
www.herzog.co.jp

China

HERZOG (Shanghai) Automation
Equipment Co., Ltd.
Section A2, 2/F, Building 6
No. 473, West Fute 1st Road,
Waigaoqiao F.T.Z., Shagnhai,
200131
P.R.China
Phone +86 21 50375915
info@herzog-automation.com.cn
www.herzog-automation.com.cn